1. DESCRIPTION

The LFG-1300S Figure 1, is an extremely versatile signal source for design, development and service applications.

It provides a choice of sine, triangle, sawtooth, square and pluse signals over the frequency range of 0.002 Hz to 2 MHz. Voltage control of the frequency of the master oscillator permits linear or logarithmic sweep using internal or externally-applied sweep control. In addition, an internal modulator permits amplitude modulation with the option of a suppressed-carrier mode. Calibrated control of the output level is provided, as well as variable dc offset. A fixed TTL output is also provided.

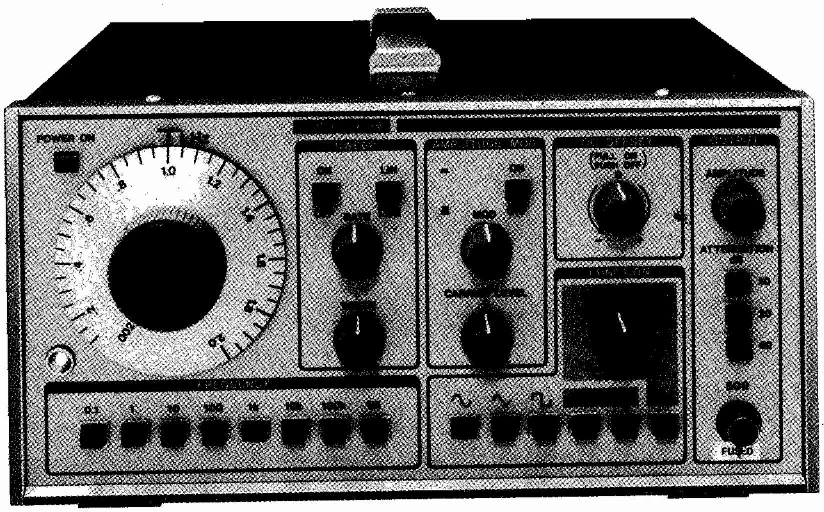


Figure 1. LFG-1300S Function Generator

2. FEATURES

1. Wide frequency range, 0.002 Hz to 2 MHz in eight ranges.
2. Choice of output waveform includes sine, triangle, sawtooth square and pulse signals. In addition, control of dc offset permits the superimposition of d-c levels on the output signal.
3. A separate TTL output with a fan-out of 20 permits direct drive of TTL logic circuits.
4. Low distortion, a THD of 0.5% or less is maintained throughout the frequency range.
5. Built in swept frequency function provides a choice of linear or logarithmic sweep with variable sweep width and rate. A sawtooth for horizontal axis drive to an oscilloscope is provided.
6. External sweep-control voltage applied at the VCG connector, permits external control of frequency, sweep, or frequency modulation of the master oscillator.
7. An internal amplitude modulator permits both AM and double-sideband suppressed-carrier modulation for communications and instrumentation applications.
8. Step attenuators provide 10, 20, and 40 dB steps for a total attenuation of 70 dB into a 50 ohm load. An output control provides continuous control of signal level into the attenuator.

3. SPECIFICATIONS

Frequency Range	(0.02 Hz–2 MHz in 8 ranges, uncalibrated to 0.002 Hz): 0.02 Hz–0.2 Hz. 0.2 Hz–2 Hz. 2 Hz–20 Hz. 20 Hz–200 Hz. 200 Hz–2 kHz. 2 KHz–20 kHz. 20 KHz–200 kHz. 200 KHz–2 MHz.
Accuracy	0.02 Hz to 200 kHz: ± 3% rdg, ± 3% f.s. 200 kHz to 2 MHz: ± 5% rdg, ± 5% f.s.; for sawtooth
Waveforms	
Sine wave	
Voltage	20 V p-p (7 V rms) open circuit.
Distortion	10 Hz–20 kHz; < 0.5% 20 kHz–100 kHz; < 1% 100 kHz–2 MHz; < 3%
Flatness	0.02 Hz–2 MHz within ± 0.3 dB.
Triangle	
Voltage	20 V p-p open circuit.
Symmetry	1% (0.02 Hz to 100 kHz).
Sawtooth	
Voltage	20 V p-p open circuit.
Symmetry	15:85 or 85:15 fixed.
Square Wave Output	
Voltage:	20 V p-p open circuit.
Symmetry	1% (0.02 Hz to 100 KHz).
Rise Time	Less than 100 ns.
Pulse	
Voltage	20 V p-p open circuit.
Symmetry	9:1–1:9 Continuously Variable.
TTL Output	
Fan Out	20 TTL.
DC Level	Controlled by dc Offset: ± 10 V.
Sweep Capabilities	
Type	Linear or Logarithmic.
Rate (duration)	0.2 Hz to 50 Hz (5 s to 20 ms).
Width	1,000: 1 max, continuously variable.
Ramp Output (for oscilloscope H-input)	0 to + 10 V.
AM Capabilities	
Modulation Level	0 to 100%.
Carrier Level	Adjusted by front panel control.
Output Level Control	
Attenuator	10, 20, 40 dB (0-70 dB, 10 dB steps).
Impedance	50 Ω.
Max Level	20 V p-p adjustable.
Rear Panel Inputs/ Outputs VCO	Input for external frequency control signal.
Mod	Input for AM signal.
GCV	Output for oscilloscope H-Axis.
TTL	Fixed level TTL output, fan out = 20.
Physical	
Size (WxHxD)	250 X 125 X 250 mm.
Weight	9 lbs, 4 kg approx.
Power Requirements	100, 117, 200 or 234 V ac, 50–60 Hz.

4. CONTROLS AND CONNECTORS

Front Panel. Refer to Fig. 4-1.

(1)	POWER ON Switch	Set to on, to power the unit. The pilot lamp (17) will light.
(2)	Frequency dial	Provides continuous control of frequency within the range selected by (16). To obtain operating frequency multiply dial reading by selected range button (16)
(3)	SWEEP ON-OFF Switch	Master oscillator is swept when ON; operates CW when OFF.
(4)	RATE Control	Controls the sweep repetition rate from 0.2 Hz (5 S) to 50 Hz (20 mS).
(5)	LIN-LOG Switch	Selects linear or logarithmic sweep mode.
(6)	MOD Control	Controls percentage of modulation for AM operation.

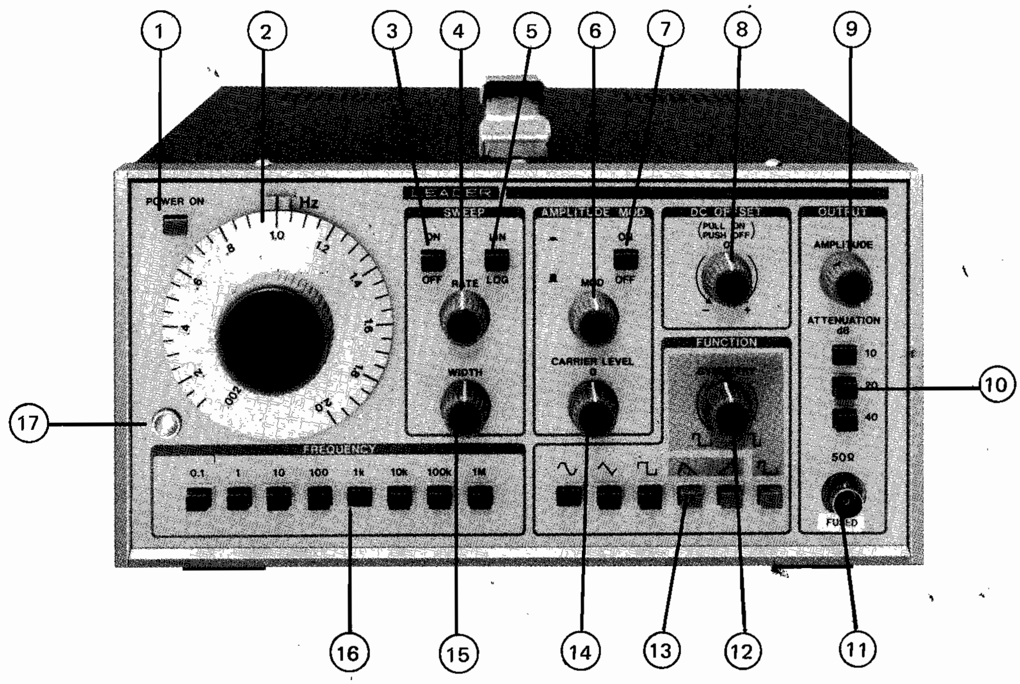


Figure 4-1.

(7) **AM ON-OFF Switch** — Turns on AM modulator and accepts modulating signal from the MOD IN jack on the rear panel.

(8) **DC OFFSET Control** — Adds a dc offset voltage to the output signal. Pull out to activate dc offset. Voltage added is positive for CW rotation and negative for CCW rotation. When all function selector buttons are off (out from panel) the dc offset, alone, is available at the output connector. Depress this control to remove dc offset.

(9) **AMPLITUDE Control** — Provides continuous level control into the output attenuators.

(10) **ATTENUATION Switches** — Provide calibrated attenuation values of 10, 20 and 40 dB. Total attenuation is 70 dB when all switches are depressed.

(11) **Fused 50 Ω Output Connector** — Delivers all output signals into the intended 50 ohm termination.

(12) **SYMMETRY Control** — Provides control of symmetry for pulse waveform only. When set to mid range, symmetrical square waveforms are obtained. Turning the control CW increases the width of the positive excursion; CCW rotation reduces the width of the positive excursion. Repetition rate is not altered by changing the setting of the SYMMETRY control.

(13) **Function push-buttons** — These five push-buttons select sine, triangle, square, pulse, or sawtooth waveforms.

(14) **CARRIER LEVEL Control** — Controls the carrier ratio in the AM mode, and permits balanced operation whereby the carrier is suppressed and double sideband, suppressed-carrier operation is obtained.

(15) **WIDTH Control** — Sets the upper frequency limit in sweep generator operation; the frequency dial (2) sets the lower limit. A maximum frequency ratio of 1000 to 1 is available.

(16) **FREQUENCY Range Push-Buttons** — Selects the frequency range of operation. Multiply the frequency dial reading by the factor printed above the depressed push-button.

(17) **Pilot lamp** — Glows green when the unit is powered.

Rear Panel. Refer to Fig. 4-2.

(18) **VCG IN Connector** — Accepts input for external *V*oltage *C*ontrol *G*enerator applications. Maximum frequency range is obtained with a voltage range of 0 to 10 V.

(19) **GCV OUT Connector** — Provides *G*enerator *C*ontrol *V*oltage output proportional to the frequency of operation and varies between 0 and +5 V dc according to the setting of the front panel frequency dial.

(20) **TTL OUT Connector** — Provides TTL-level drive signals as determined by the front-panel control settings.

(21) **MOD IN Connector** — Accepts externally-applied signals to amplitude modulate the carrier sup-

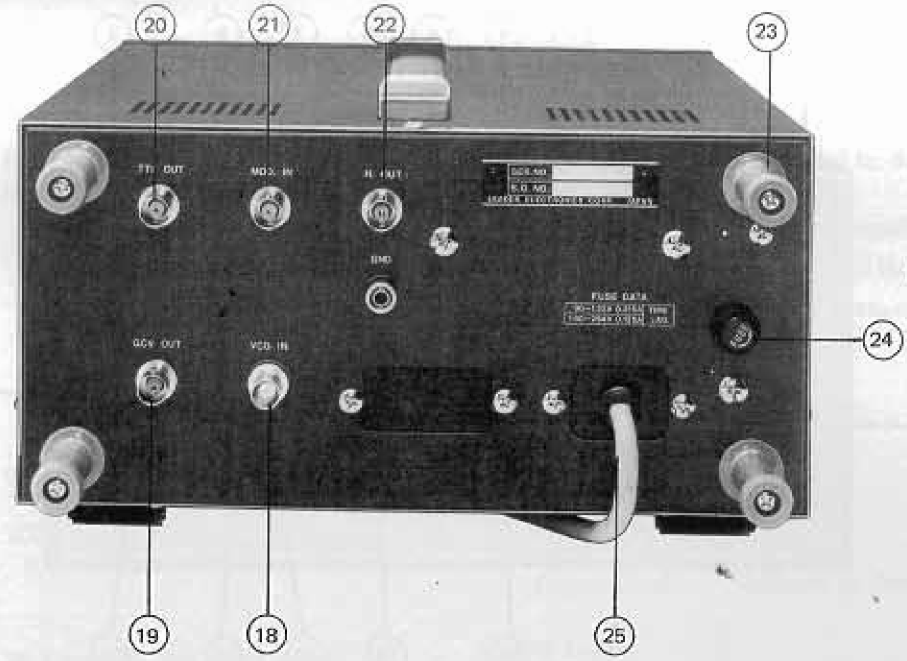


Figure 4-2.

		plied by the internal VCO. Optimum level is 0.3 Vrms. Excessive input level can cause distortion due to saturation; insufficient input level can result in nonlinear modulation.
(22)	H OUT Connector	Provides X-axis deflection for an oscilloscope used to display frequency response during sweep operations. Sawtooth signals from 0 to +1 V are repeated at the rate set by the RATE control (4).
(23)	Rear panel legs	Permit the unit to be supported by the rear panel and provides a means for power cord storage.
(24)	FUSE	315mA for 117V operation.
(25)	AC LINE Connector	

5. OPERATING INSTRUCTIONS

5.1 Operating Precautions

5-1-1

Line voltage should be within ±10% of 117 Vac.

5-1-2

CAUTION

Do not apply external voltages to the output connector. Use a suitable blocking capacitor if the circuit point to be driven is above or below ground potential.

5.2 Signal Generator Operation

5-2-1 Sine Wave Signals

NOTE

The generator synthesizes sine waves using shaping networks that employ multiple diodes. Although overall distortion is as specified in section 3, the output waveform may contain small transient spikes.

1. For most applications, terminate the output cable in 50 ohms.
2. Set the front panel controls as shown in Fig. 5-1.
3. Set operating frequency by selecting the multiplier with the appropriate FREQUENCY push-button and setting the dial for the desired frequency. For example, to obtain a 600 Hz sine wave set the dial to 6 and depress the 100 FREQUENCY push-button.
4. Output level is determined by the setting of the AMPLITUDE control. With all attenuator switches released (out), output level varies between 0.35 and approximately 3.5 V rms throughout the range of the AMPLITUDE control. These values apply when the generator output is properly terminated in 50 ohms. Multiply by 2 (add 6 dB) if the generator output is not terminated.
   Depressing any combination of the ATTENUATOR push-buttons inserts attenuation equal to the sum, in decibels, indicated on the push-buttons that are depressed. For example, 70 dB of attenuation is inserted when all three push-buttons are depressed. Table 5-1 shows the relation between attenuator settings and output voltage for both open-circuit and terminated outputs.

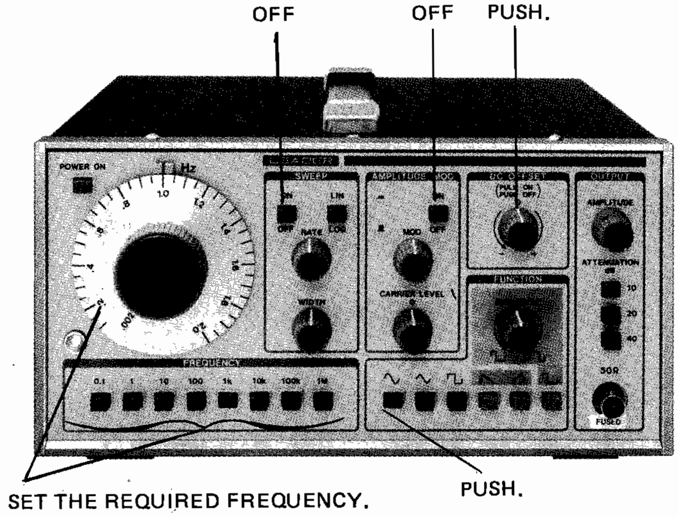


Figure 5-1. Sine Wave Operation

5-2-2 Triangle-wave Signals

1. Follow paragraph 5-2-1, but depress the triangle wave push-button. Refer to Fig. 5-2.
2. Output levels for complex waves are usually measured in peak-to-peak values. The right half of Table 5-1 gives the relation between AMPLITUDE and ATTENUATOR settings in peak-to-peak values for both terminated and open-circuited output conditions.
3. Triangle signals are particularly useful for detecting the onset of clipping in an amplifier, as indicated by a rounding of the peaks. Refer to Fig. 5-3.

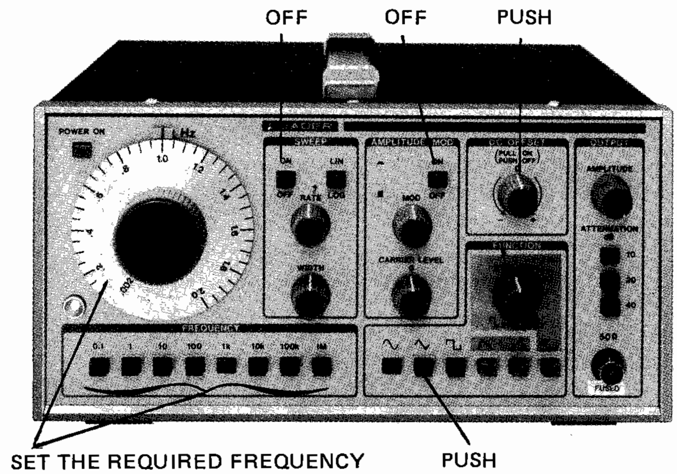
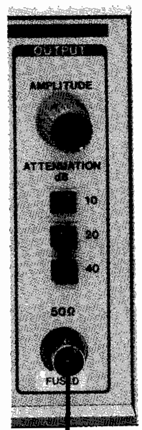
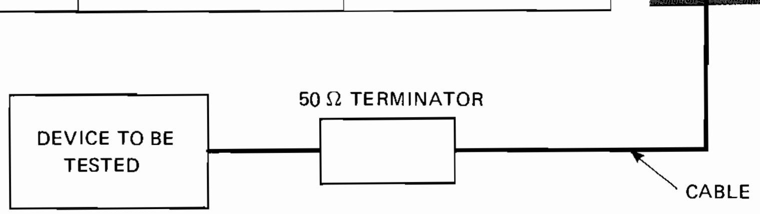


Figure 5-2. Triangle Wave Operation

Table 5-1
Relationship Between Output Voltage and Attenuator Setting

Attenuation dB	Setting of attenuators dB			AMPLITUDE output-voltage range			
				Sine wave Vrms		Triangle/square wave V(p-p)	
				Open	Termination	Open	Termination
	10	20	40	MIN~MAX	MIN~MAX	MIN~MAX	MIN~MAX
0				0.7 ~ 7.0	0.35 ~ 3.5	2 ~ 20	1 ~ 10
10	10			0.22 ~ 2.2	0.11 ~ 1.1	0.64 ~ 6.4	0.32 ~ 3.2
20		20		70mV ~ 0.7	35mV ~ 0.35	0.2 ~ 2	0.1 ~ 1
30	10	20		22mV ~ 0.22	11mV ~ 0.11	64mV(p-p) ~ 0.64	32mV(p-p) ~ 0.32
40			40	7mV ~ 70mV	3.5mV ~ 35mV	20mV(p-p) ~ 0.2	10mV(p-p) ~ 0.1
50	10		40	2.2mV ~ 22mV	1.1mV ~ 11mV	6.4mV(p-p) ~ 64mV(p-p)	3.2mV(p-p) ~ 32mV(p-p)
60		20	40	0.7mV ~ 7mV	0.35mV ~ 3.5mV	2mV(p-p) ~ 20mV(p-p)	1mV(p-p) ~ 10mV(p-p)
70	10	20	40	0.22mV ~ 2.2mV	0.11mV ~ 1.1mV	0.64mV(p-p) ~ 6.4mV(p-p)	0.32mV(p-p) ~ 3.2mV(p-p)





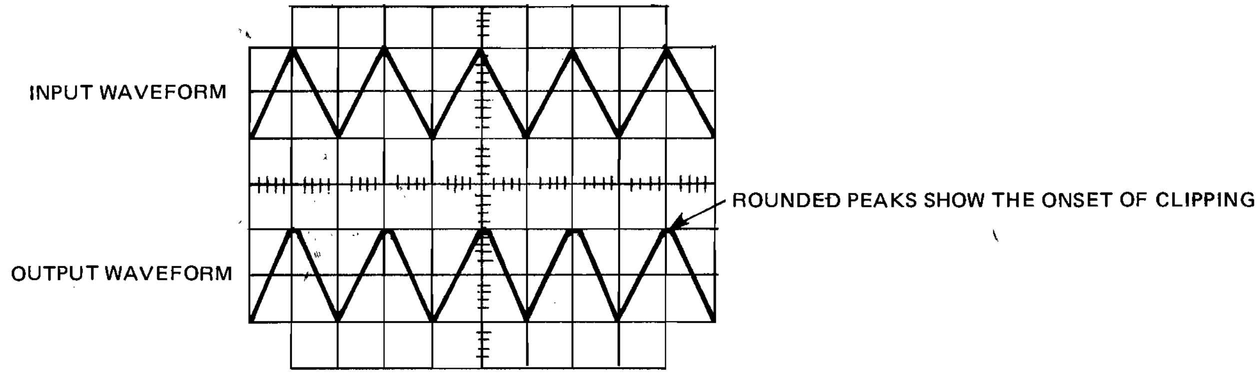


Figure 5-3. Using Triangle Waveform to Detect Clipping

5-2-3 Square-wave Signals

1. Follow paragraph 5-2-1, but depress the square wave push-button. Refer to Fig. 5-4.
2. Output levels for complex waves are usually measured in peak-to-peak values. The right half of Table 5-1 gives the relation between AMPLITUDE and ATTENUATOR settings for both terminated and open-circuited output conditions.

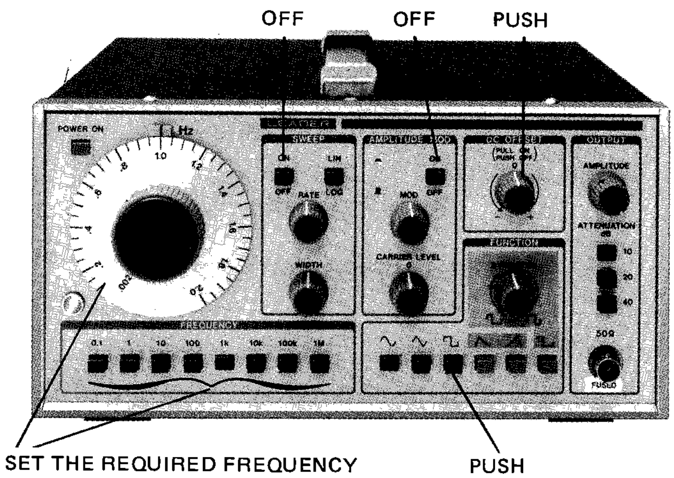


Figure 5-4. Square Wave Operation

5-2-4 Sawtooth Signals

1. Follow paragraph 5-2-1, but depress the or push-buttons for a falling or rising voltage ramp. Waveform symmetry is fixed at a value of 15:85 or 85:15. See Fig. 5-5.

5-2-5 Pulse Signals

1. Follow paragraph 5-2-1, but depress the (pulse) push-button.
2. Adjust SYMMETRY control for the desired pulse width or duty cycle. When the SYMMETRY control is set to approximately mid-range a symmetrical square wave of 50% duty cycle is produced. Turning the SYMMETRY control CCW decreases the duration of the positive portion of the waveform. Turning the control CW from center increases the duration of the positive portion of the waveform. In this way a wide range of both positive-negative pulse widths is available.
3. Adjust DC OFFSET control to obtain the desired base level for the pulse signal. Refer to Section 5-3.

5.3 DC Offset

Output signals are resolved around zero when the DC OFFSET control is depressed. Pull out this control to activate the dc offset. At the mid-range setting the dc offset voltage is zero. Turn clockwise to obtain positive dc offsets, counterclockwise to obtain negative dc offsets. **Maximum load current is 100mA into 50 ohms.** Refer to Fig. 5-6.

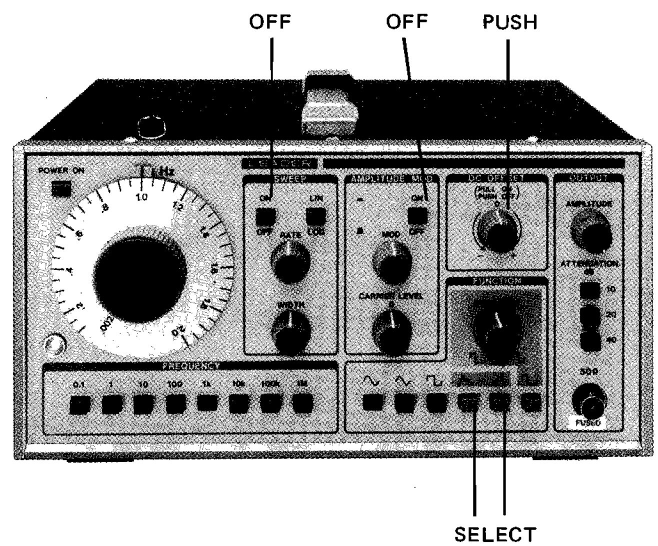


Figure 5-5. Sawtooth Operation

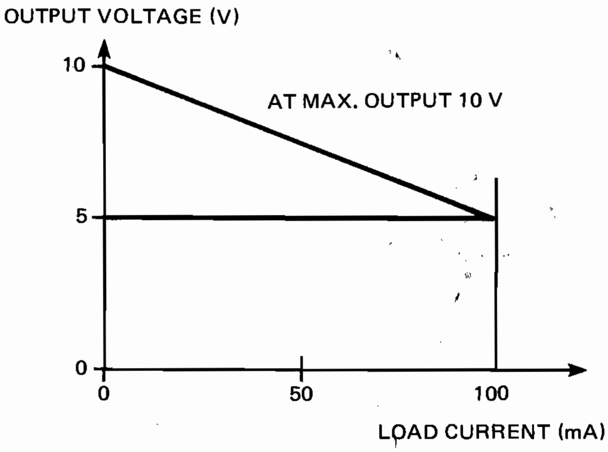


Figure 5-6. Relationship of Maximum Load Current to Offset Voltage

The offset voltage is added at the input to the attenuators. Therefore switch all attenuators out when using the offset function. Refer to Fig. 5-7.

To measure the dc offset voltage at the OUT connector, depress one of the function push-buttons partially so that all push-buttons are released (out from panel); the dc offset voltage can now be measured without the effect of ac signals.

DC offsets, can be used to set up bias conditions in direct coupled circuits. It is also extremely useful in obtaining pulses or other signals with a variable reference level. A direct-coupled oscilloscope is useful in setting these conditions.

NOTES:

1. High-amplitude output signals used in conjunction with dc offset can result in clipping at the plus and minus 10 volt levels. (±5 V when the output is terminated.) Refer to Fig. 5-8. Reduce AMPLITUDE as needed to prevent clipping.

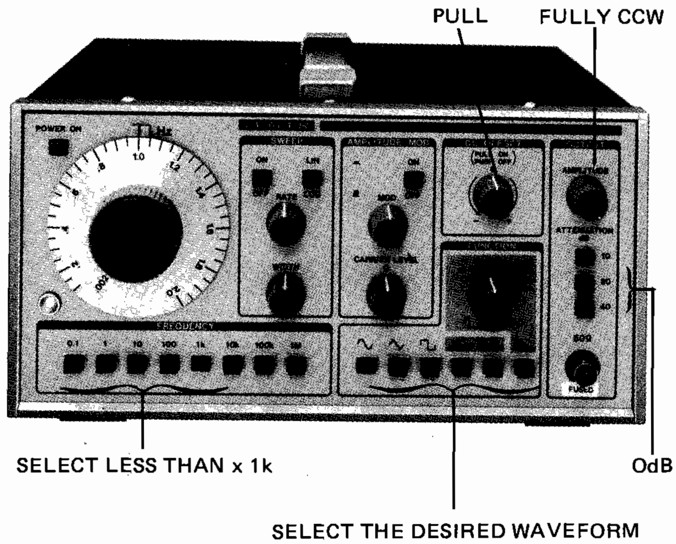


Figure 5-7. DC Offset Operation

2. A normal dc offset of a few tenths of a volt exists when the DC OFFSET knob is pushed in. To eliminate this residual offset, turn DC OFFSET on by pulling out the control. Reset DC OFFSET for zero volts DC.

3. Attenuator PCB T-2004C is fused against damage with F-2 see Figures 7-3 and 7-7.

5.4 TTL Output

The TTL OUT connector will supply square or pulse signals at TTL levels for a maximum fan out of 20 TTL gates.

Level conversion is required to drive CMOS gates because the threshold levels are different. Figure 5-9 shows how the conversion can be made using an open collector TTL device such as the SN7406. An alternative is to use a TTL-CMOS interface IC such as the SN75367.

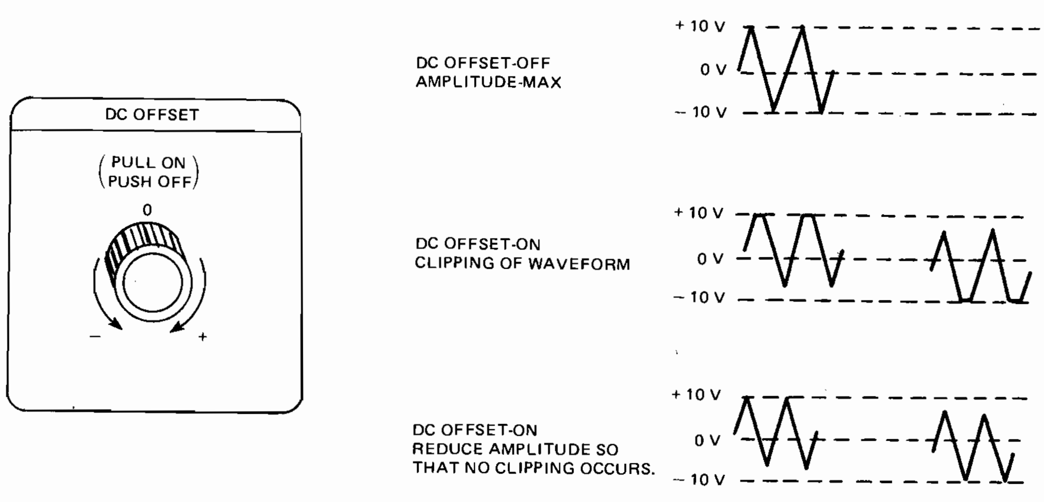


Figure 5-8 Clipping in DC Offset Operation

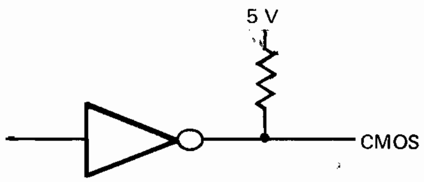


Figure 5-9 TTL- to -CMOS Level Conversion

5.5 Sweep Generator Operation

1. Set up the generator for sine wave operation as in paragraph 5-2-1.
2. Connect the H OUT connector on the rear panel to the X axis (H deflection) input of the oscilloscope or X-Y plotter.
3. Depress the SWEEP ON-OFF switch to ON.
4. Set the LIN-LOG switch as required.
5. Select the frequency range key so that the upper sweep frequency limit will be found in that range.
6. Set the lower sweep frequency limit with the frequency dial.
7. Set the upper sweep frequency limit using the WIDTH control.
8. Set the sweep RATE as desired.

The rate should be at 1/10 or less of the lower sweep frequency limit.

For example, a 20Hz to 20 kHz log sweep is obtained as shown in Fig. 5-10. Select the X 10 KHz range key and set the frequency dial to 0.002 (20 Hz). Set the WIDTH control for a maximum sweep frequency of 20 kHz. Set sweep rate to 0.5 sec (2 Hz) or longer.

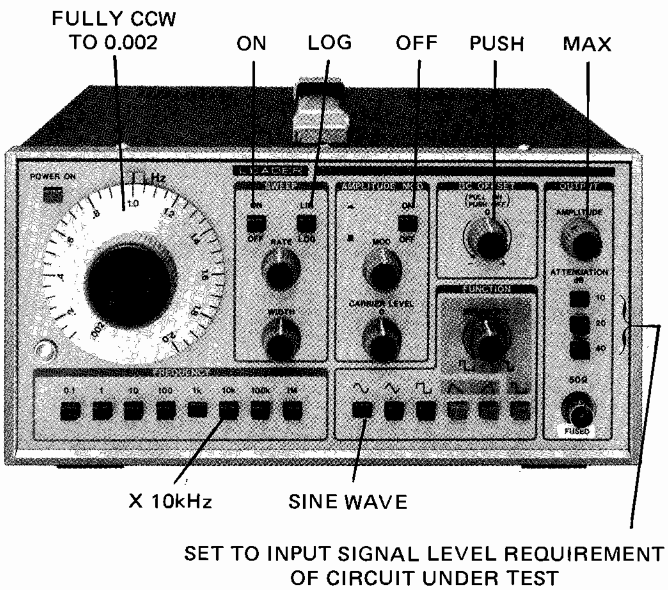


Figure 5-10. Sweep Frequency Operation

Calibration of upper and lower limits of the sweep range can be accomplished as follows:

a. Connect an oscilloscope to the GCV OUT connector on the rear panel. Set the oscilloscope for direct coupled operation; turn horizontal deflection off. Set vertical sensitivity to 0.5 V/cm.

b. Turn the sweep off on the LFG-1300S.

c. Set the front panel frequency dial to the intended lower sweep frequency limit.

d. Adjust oscilloscope vertical position control to locate the spot on the next to lowest graticule line. See Fig. 5-11*a*.

e. Set the frequency dial to the intended upper limit of the sweep range. Change the oscilloscope sensitivity if spot deflection is insufficient or off scale.

f. Note the position of the new vertical position of the spot. See *b* of the figure. The two reference points on the oscilloscope now represent the control voltage limits for the limits of the sweep range.

g. Reset the frequency dial to the low limit of the sweep range.

h. Depress the SWEEP push-button.

i. Adjust the WIDTH control so that the top of the vertical trace is at the graticule position established in Step f.

j. Reset the frequency so that the bottom of the vertical trace is on the lower reference graticule line. Reset WIDTH, if necessary so that the vertical trace lies between the two reference marks. The sweep frequency range is then set to the intended limits.

9. Connect the terminated output cable to the equipment under test. Refer to Fig. 5-12. Be sure to use a suitable blocking capacitor if the feed point is above ground or if the 50 ohm terminator will alter bias conditions in the circuit under test.

5.6 Amplitude Modulator Operation

1. Set the operating controls for sine wave operation. Refer to paragraph 5-2-1. Set the frequency controls for the desired carrier frequency.
2. Apply the modulating signal to the MOD IN terminal on the rear panel. The optimum input signal level is 0.3 Vrms. Higher levels will cause distortion due to overmodulation and clipping. Lower levels tend to deteriorate modulation linearity.
3. Depress the AMPLITUDE MOD ON-OFF switch and monitor the output signal.
4. Set CARRIER LEVEL to 0 (midrange).
5. Set the MOD control fully CW.
6. Set the CARRIER LEVEL control for an indication of 100% modulation. See Fig. 5-13. The MOD control will now vary the percentage of modulation between zero and 100%. Reset the MOD control for the desired percentage of modulation. Refer to Fig. 5-13.
7. Double-sideband (DSB) suppressed-carrier operation can be obtained by turning the CARRIER control counterclockwise until the DSB waveform shown in Fig. 5-13 is obtained.

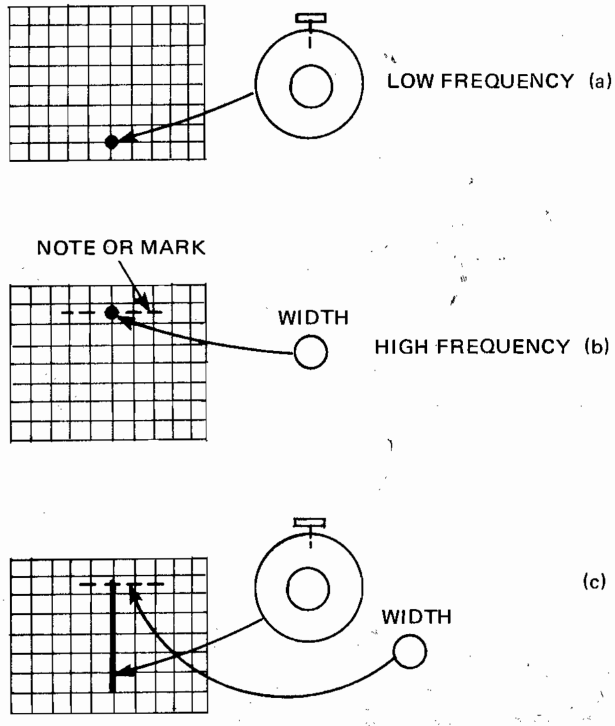


Figure 5-11

5.7 External Frequency Control

External control of signal frequency is achieved by applying a dc control voltage to the VCG connector on the rear panel.

The applied control voltage operates in conjunction with the front-panel frequency push-buttons to obtain the desired frequency. A positive-going voltage increases frequency.

For example, if the frequency dial is set fully CW, to 0.002 and a positive control voltage is applied, the frequency increases. At the maximum input of +10 V the operating frequency will be twice that selected by the range push-button. If the 1 kHz range is selected, output frequency will be 2 kHz when a +10 V dc is applied.

If the frequency dial is set to 2.0, and a negative control voltage of −10 V dc is applied, the frequency decreases to 0.002 times the range selected.

The relation between control voltage, frequency-dial settings and output frequency is described for the 1 kHz range in Fig. 5-14. The maximum frequency control range is 1000 to 1.

5.8 Frequency (Sweep) Modulation by External Control

The master oscillator may be frequency modulated by an ac signal applied at the VCG connector. The input impedance at the VCG connector is 10 kohms.

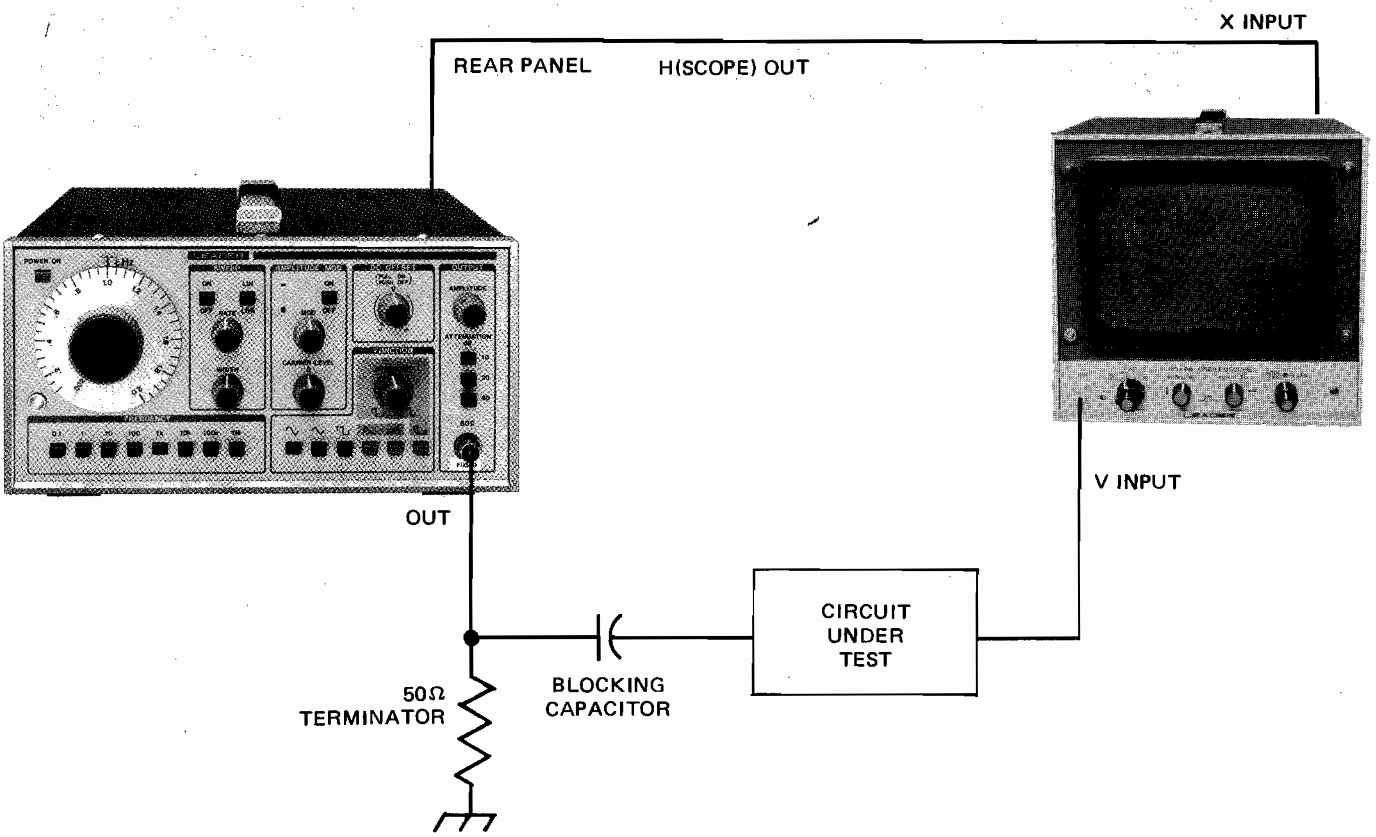
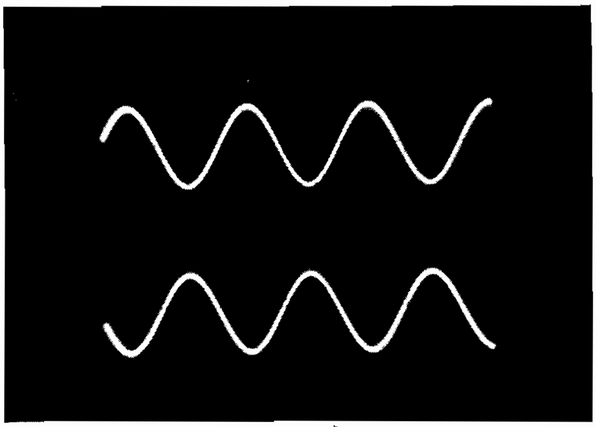
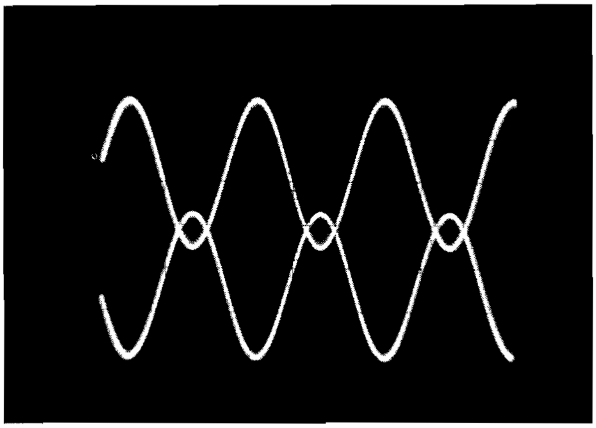


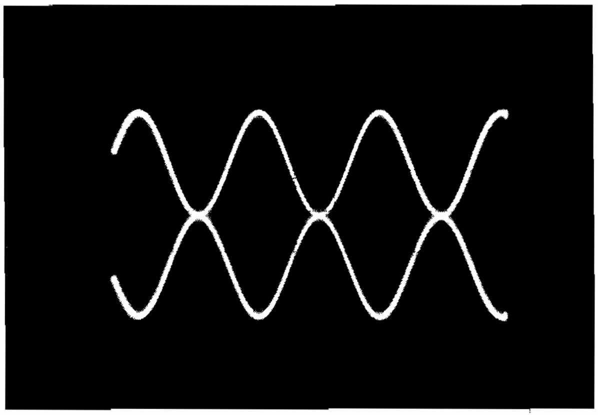
Figure 5-12 Set up for Frequency Response Measurements



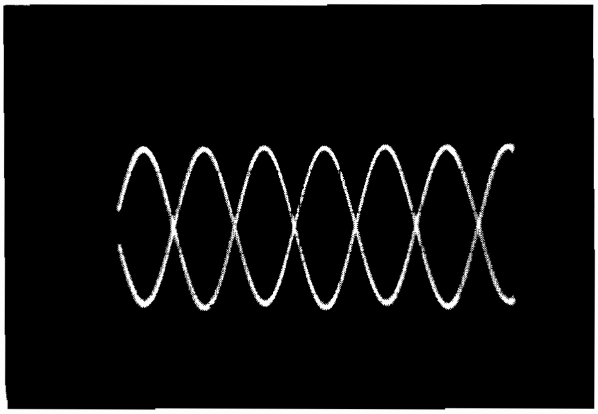
50% MODULATION



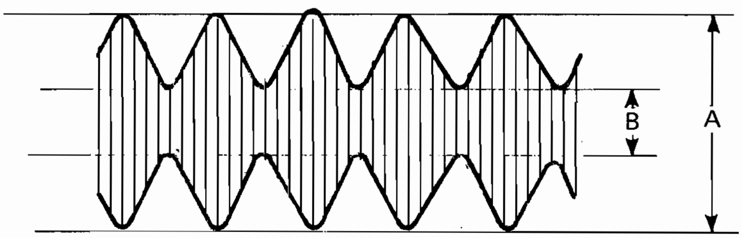
OVER 100% MODULATION



100% MODULATION



DSB (DOUBLE SIDE BAND)



HOW TO DETERMINE MODULATION % FROM SCOPE WAVEFORM

$$M\ (\text{MODULATION}) = \frac{A - B}{A + B} \times 100\%$$

Figure 5-13. AM Waveforms

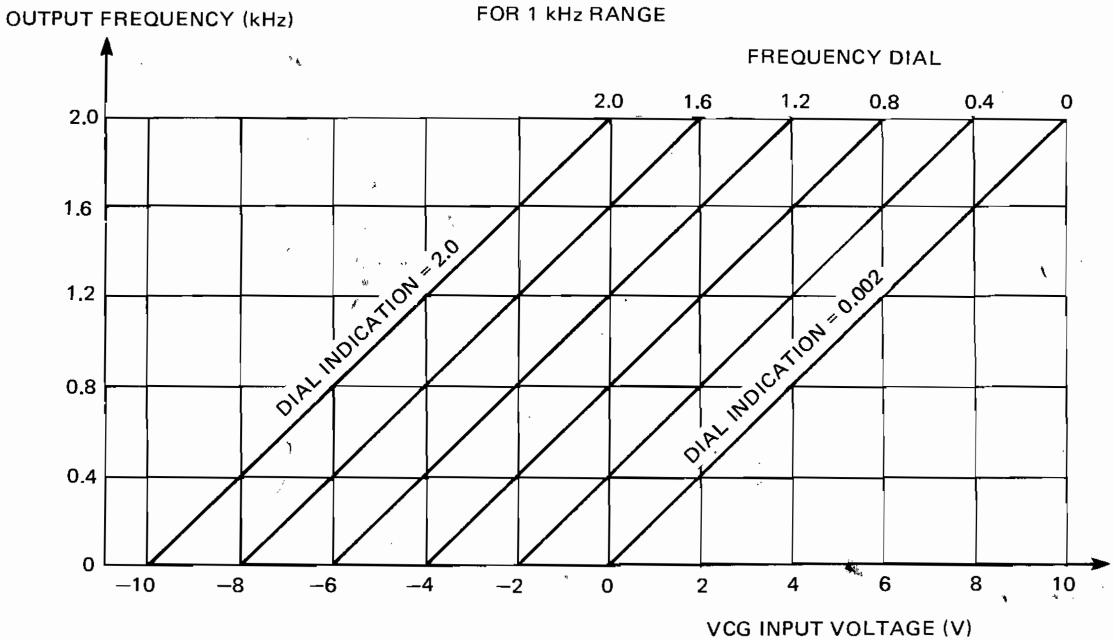


Figure 5-14. Relationship of Output Frequency, Frequency Dial Setting and VCG Input Voltage.

Deviation or frequency shift is determined by the applied voltage and the selected frequency range. Table 5-2 shows the relation between the selected range and the frequency shift per applied control voltage. The shift is given per volt of applied control.

For example, consider a required deviation of 10 kHz at a center frequency of 500 kHz. Since 500 kHz is obtained in the X1M range, the frequency shift is 200 kHz per volt, as indicated in Table 5-2.

The required input voltage can be calculated as follows.

$$\text{Input voltage} = 1\ \text{V} \times \frac{10\ \text{kHz}}{200\ \text{kHz}}$$

$$= 0.05\ \text{V} = 50\ \text{mV}$$

Thus the 10 kHz deviation is obtained with an ac signal of 50 mV peak-to-peak.

Table 5-2
Relationship Between Frequency Range and Frequency Shift per VCG Input Volt

Frequency range	×0.1	×1	×10	×100	×1k	×10k	×100k	×1M
Frequency shift per 1 V	0.02Hz	0.2Hz	2Hz	20Hz	200Hz	2kHz	20kHz	200kHz